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# A Review of the Draft Lambda-Cyhalothrin Criteria Derivation Document Prepared by Tessa Fojut and Ronald Tjeerdema

**Lenwood Hall**
**University of Maryland**
**Wye Research and Education Center**
**P. O. Box 169**
**Queenstown, Maryland 21658**

The goal of this Fojut and Tjeerdema (2010) document was to develop water quality criteria for the pyrethroid insecticide lambda-cyhalothrin using a new methodology described in detail in TenBrook et al., 2009. The need for a new methodology was identified by California's Central Valley Regional Water Quality Control Board (CVRWQCB, 2006). My review comments are presented below as general comments and specific page by page comments.

## General Comments

- The authors are to be commended for striving to use a very thorough process for reviewing the scientific credibility of each lambda-cyhalothrin toxicity study used for criteria development. The use of scientifically valid toxicity data is the foundation of credible criteria. However, I am concerned because the current review process is cumbersome and somewhat flawed which could result in invalid studies being accepted for criteria development or valid studies being rejected. The current data review process described in TenBrook et al. (2009) requires the completion of 4 forms if the relevance score in Table 3.6 is $\geq$ 70. I would suggest initially prioritizing the critical elements of each study that **must** be acceptable before conducting any further study evaluation. Critical elements of a study that must be acceptable before evaluating any other components of the study are: (1) Is the current document under review the primary (original) source of the data (don't use data summaries from a secondary source)?; (2) Is the control endpoint (survival, growth, or reproduction) acceptable based on peer-reviewed guidelines?; (3) Was the duration of exposure reported?; (4) Were adverse effects evaluated using exposures to a single pesticide?; (5) Were effects reported for relevant endpoints (e.g., survival, growth or reproduction)?; (6) Was more than one dose/concentration used in a toxicity test?; (7) Was the test species reported?; (8) Was the chemical form (% active ingredient) of the test material reported?; and (9) Was a dose response evident? In the current data review process, a study with unacceptable control survival receives a 7.5 point reduction (see Table 3.6 in TenBrook *et al*. 2009) but can still be rated acceptable for criteria development. This is a clear case where an invalid study could be used for criteria development. Conversely, it seems unreasonable and highly restrictive in the grading process, described in TenBrook et al. 2009, to deduct points for the following study elements if control response is acceptable: (1) tolerance ranges for various water

quality parameters (e.g., hardness, alkalinity, conductivity, and pH – a maximum of 7 points could be deducted); (2) dilution water information (2 point deduction) and (3) information on prior contaminant exposure to test organisms that is rarely mentioned in a document (4 point deduction). For example, in many cases tolerance ranges for water quality parameters such as hardness, alkalinity, conductivity, and pH are simply unknown for a test species. In summary, I am concerned that both valid toxicity studies could be graded as unacceptable, and that studies of questionable scientific merit could be graded as acceptable using the current data review process.

- In order to develop the chronic criterion, Acute to Chronic Ratios (ACRs) were developed for 3 species (2 freshwater and 1 saltwater species in Table 8) using the corresponding acute LC50 values and the MATCs (chronic values). The MATC (maximum acceptable toxic concentration) is the geometric mean of the No–Observed-Effect-Concentration (NOEC) and the Lowest-Observed-Effect-Concentration (LOEC). These MATC, NOEC, and LOEC values have a high degree of uncertainty because they are determined by the range of test concentrations (dilution series) and the sample size used in the toxicity test. For example, one of the tested concentrations will be the NOEC and if different test concentrations are used the NOEC will change. The peer reviewed literature has a number papers that discuss the uncertainty associated with using NOEC, LOEC and MATC values in the regulatory process because these values have no statistical confidence (Newman, 2010; Crane *et al*., 2010; among others). In cases where a suboptimal design is used, higher NOEC and LOEC values may be reported due to low statistical power and high error variance. In contrast, when a superior study design is used, lower NOEC and LOEC values could be reported. Due to the uncertainty associated with the use of MATC, NOEC and LOEC values it is recommended that EC50s, EC25s or EC20s should be used to represent chronic values.
- The microcosm and mesocosm studies presented in Table 10, where 5 of these studies were rated as reliable, are not used to their full potential in the criteria derivation process. Community level NOEC values from these studies are merely used as confirmation that the criteria are low enough and sufficiently protective. For example, a study graded as reliable (Schroer *et al.*, 2004) reported a community level NOEC of 10 ng/L while other investigators (Van Wijngaarden *et al*., 2006; Roessink *et al*., 2005) have reported significantly higher community level NOECs (the lowest was < 10,000 ng/L) from reliable studies. The weight of the microcosm/mesocosm data in total suggests that the proposed acute and chronic lambda-cyhalothrin criteria (1 ng/L) are highly over protective of resident biota and should be reconsidered to account for the "**reasonable protection of designated uses**" as stated in the Porter Cologne Act. Note that the legal standard for protection of beneficial uses, such as warm or cold freshwater habitat, by State and Regional Boards in California is "**reasonable protection**" not "**full protection**" (See *United States v. State Water Resources Control Board* (1986) 182 Cal. App.3d82, 121-122) so there is some flexibility in establishing criteria as 100% protection of all individual species all the time is not required.

- The basis for using 1-h (acute criterion) and 4-d (chronic criterion) averaging periods for allowable exposure duration for pesticides such as lambda-cyhalothrin in the Central Valley is not appropriate. These two averaging periods were likely selected because they are used by USEPA in their criteria development method (Stephen et al., 1985). It is important to remember that the USEPA water quality criteria development approach initiated in the mid 1980s was primarily developed for POINT SOURCE discharges where constituents such as ammonia are measured at frequent intervals (hourly or daily). However, for pesticides hourly measurements are rare for monitoring efforts in California. Even daily measurements for four consecutive days would be an exception and not the rule for pesticide monitoring studies in the Central Valley. Pesticide data collected from monitoring studies in the Central Valley and obtained from California's Department of Pesticide Regulation should be reviewed to determine the most common frequency of pesticide measurements (i.e., once a month for a year) and these data could be used to select the most appropriate averaging periods for both acute and chronic criteria. Further highlighting the issue of appropriate exposure selection is the fact that acute aquatic toxicity test durations typically range from 2 to 10 days, while chronic studies can be 21 days in duration or longer. Longer-term chronic averaging criteria of greater than 4 d would thus more appropriately fit common standards for chronic toxicity testing and risk assessment.
- In setting an allowable frequency of exceedence of the acute and chronic criterion, the key question is how much time is needed for organisms at various levels of organization to recover from brief pulse exposures to contaminants. The proposed criteria method recommends an allowable frequency of exceedance of once in three years. This is the same frequency of exceedance used by the USEPA in their criteria method (Stephen et al., 1985). TenBrook et al. 2009 in their criteria development document have stated that the 3-year frequency of exceedence was supported by minimal data. The receptor group (most sensitive biological assemblage) for any given pesticide should be considered when establishing the acceptable frequency of exceedance for a specific type of pesticide. For example, the receptor group for lambda-cyhalothrin consists of various benthic macroinvertebrates (amphipods - *Hyalella*, insects, isopods etc.) . The most sensitive species to lambda-cyhalothrin is the amphipod *Hyalella azteca*. The life cycle of *Hyalella* is approximately 1 to 1.5 months (egg to egg carring female) depending on water temperature. Therefore, a once in three years exceedance is overprotective for a species such as *Hyalella* that can recover fairly quickly in the environment. In contrast, for species with long life cycles (greater than 5 years) such as various fish, a once in three year exceedance may be appropriate. For lambda-cyhalothrin there should be some flexibility for the frequency of exceedance component of the new criteria that would allow the use of life histories for appropriate receptor species in order to determine the most appropriate frequency of exceedance. The authors should also explore the use of the binomial approach for determining the number of pesticide exceedences needed before a violation occurs. The California State Board uses the binomial approach for listing and delisting impaired water bodies in the State based on exceedences of both toxicants (i.e. pesticides) and conventional pollutants (i.e.,

pH, dissolved oxygen) (SWRCB, 2004). The binomial approach has statistical underpinnings that allows the determination of error rates associated with impairment declarations and a process to limit error rates.

- In the Bioavailability Section, it is stated as a general statement of fact that water column concentrations of pyrethroids have been reported to cause toxicity in surface waters of California's Central Valley. However, there are no references to support this point. Furthermore specific data (references) are needed to document reports of potentially toxic water column concentrations of lambda-cyhalothrin in the environment since this is the focus of this criteria document.

**Specific Comments by Page**

Page 4, Ecotoxicity data, line 1 – It is stated that 65 lambda-cyhalothrin toxicity studies were indentified and reviewed. Does this mean that data are available for 65 different species?

Page 5, parag 2, lines 5 and 6 – It is not clear how studies rated less relevant-less reliable (LL) or less relevant-reliable (LR) were useful for this criteria development exercise since these studies were judged as unacceptable for criteria development.

Page 6, top 3 lines – The final criterion was reported to one significant digit. Does the TenBrook et al. 2009 methods document address the issue of significant digits in criteria development?

Page 6, Figure 2 – For the range of values on the x axis (ln acute value, ug/l) in Figure 2, the last range on the far right lists a range of -0.62 – 1.2. Is this the correct range? It would seem that the – 1.2 value is incorrect.

Page 7, Figure 3 – Table 3 lists a total of 20 acute values used in the SSD; however, I only count 19 dots in this distribution. There are two values of 0.16 that perhaps overlap and may account for this but I just want to be sure that a value was not omitted.

Page 8, Chronic Criterion – Both the acute and chronic values are equal (1 ng/L). This suggests that the criteria derivation process may be flawed or lambda-cyhalothrin is a fast acting toxicant where only acute exposures are relevant (i.e., chronic exposures do not increase toxicity). Can the authors provide any insight on this?

Page 11, parag 4 – I am not sure what to make of this Barata et al., 2006 paper (which I have not read) that suggests slight antagonism between lambda-cyhalothrin and deltamethrin since additivity of pyrethroids is generally assumed when assessing ecological risk of multiple pyrethroids (particularly for sediment). Antagonism is not uncommon with stressors with the same mode of action as they may not have identical affinity for binding of the same sites. If antagonism is the true response of multiple mixtures of pyrethorids we may need to reevaluate how we assess ecological risk of pyrethroids.

Page 12, sensitive species, line 6 – Why are the data in Table 9 rated as LR and LL (see above comment) used for validation in this process if these data were judged to be unacceptable for criteria development?

Page 13, parag 2 – It is stated that '*Gammarus* species were examined in several studies and it was found that they were particularly sensitive to lambda-cyhalothrin". Please provide the effect concentrations (EC50s, NOECs etc.) that were used to support the statement that *Gammarus* were particularly sensitive to lambda-cyhalothrin.

Page 16, Assumptions, Limitations, and Uncertainties, parag 2, last sentence – The authors express concern over the lack of chronic data for *Hyalella*, the most sensitive species to lamda-cyhalothrin in the data set. However, this should not be a concern because the 1 ng/L (acute and chronic criteria value) is below the acute *Hyalella* LC50 value of 2.3 ng/L and the criteria derivation process supports the finding that chronic exposures do not increase lambda-cyhalothrin toxicity.

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